



Introduction
and
Concepts of Planning



INTRODUCTION

Water planning is a means to an end and not an end in itself. Its objective is the development of water resources as effectively and economically as possible to meet man's needs while at the same time protecting him from flooding and periodic drought. The high dams and man-made rivers that stand as monuments to man's ingenuity and technical skills conserve and distribute the water which is vital to his life and well-being, and shield him from its detriments. These works are conceived and planned to overcome the sometimes severe disparities between water resources as provided by nature and the timing and places of man's needs for water supply.

In the past, Texas citizens generally have been able to live wherever they chose without concern for the availability of water. Where other resources were available, a water supply was also generally available, either in the immediate vicinity or at relatively short distances. People settled, developing these supplies where they were found; investments were made, economies developed, and social and cultural values accumulated to the benefit of all citizens of the State.

Texans now, however, are able to see the limits of the State's developable water resources. Seeing these limits, recognition has also come that wise use of the available water resources is vital to the continued expansion of Texas population, economy, and culture.

By far the bulk of the water resources remaining available for development in Texas is found in the East Texas river basins. By contrast, large future water needs will be felt in areas to the west and southwest, several hundred miles distant, and for some areas, over 3,000 feet higher in elevation, where available water supplies are limited and diminishing. Cities and industries in many areas throughout the State will need more water or water of better quality than can be made available from local fresh water sources.

Furthermore, studies for the Texas Water Plan show conclusively that presently available water resources are grossly inadequate to meet Texas' future economically justified water needs. Importation of water from out-of-State sources will be essential. Without it, retrogression must inevitably occur in some sectors of the State's economy, particularly agriculture and associated agribusiness, with attendant severe social problems of unemployment and forced population relocation, and loss of financial investments.

As a result of the Texas Water Plan studies, the Congress has authorized the U.S. Corps of Engineers and the U.S. Bureau of Reclamation to investigate a possible import of water.

The Bureau of Reclamation is conducting studies of importing surplus water from the Mississippi River System into water-deficient areas in West Texas and eastern New Mexico. The Corps of Engineers is participating in these studies to determine the availability of water from the Mississippi in coordination with affected States, the locations and types of conveyance channels required for movement of water to these water-deficient areas, and the effects of such withdrawals and conveyance facilities. The Corps of Engineers was authorized in May 1966 also to determine whether any modifications or additions should be made in proposed Federal projects in relation to the Texas Water Plan, and to determine the effects of upstream developments on pollution or changes in salinity in the bays and estuaries and to recommend such improvements as are necessary to maintain or improve the quality of water in the bays.

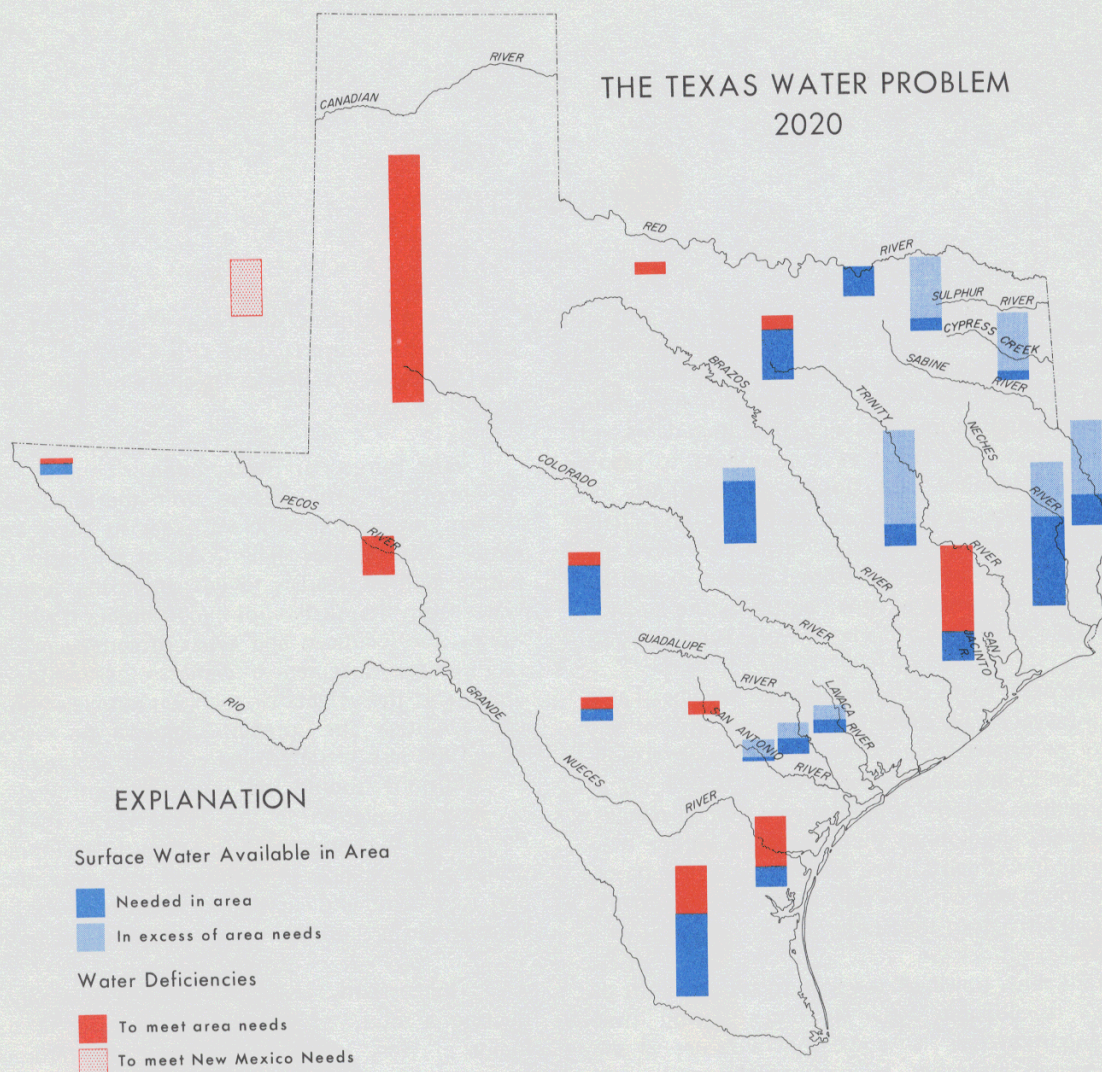
Concurrently the U.S. Geological Survey is conducting a study of the Ogallala Aquifer in the High Plains of West Texas to determine the hydraulic and hydrologic conditions in the aquifer important to its effective utilization in conjunction with an imported water supply.

By 1972 the above Federal agencies, the Water Resources Council, and the Office of Water Resources Research will have spent several million dollars for studies and investigations—including the potential import of water to Texas and eastern New Mexico, and the Ogallala Aquifer.

Texas must continue to bear its full share of responsibility for developing and implementing plans for water import, and providing for the equitable distribution within Texas of waters now or potentially available for use. Since August 1964, the State has expended approximately \$10 million in these planning activities. The time has now come to decide whether this investment in the future is to bear fruit or to be thrown away.

Statewide planning on a comprehensive long-range basis provides a guide for problem solving in advance of need; it is essential in a water-short area such

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as Texas. The Texas Water Plan has been prepared as such a guide for water policies and development, and for intergovernmental relationships affected by or affecting water resource development. The coordinated progressive Statewide development proposed will enhance the effectiveness of the large investments of capital, labor, and materials and of water related land resources required to meet Texas' water needs. It will allow a thorough and systematic evaluation of those projects which are to receive State financial aid, and will provide a basis for selection of those which are in the Statewide interest.

Water requirements have been projected for a 50-year period and means of satisfying these requirements are proposed. It is recognized that if this Plan for water development, completed in 1968, is to provide for water to meet people's needs to the year 2020, it must be subjected to continuing study, refinement, and alteration as changing needs, priorities, and wishes of the people of the State may dictate. Thus it is a Plan that is

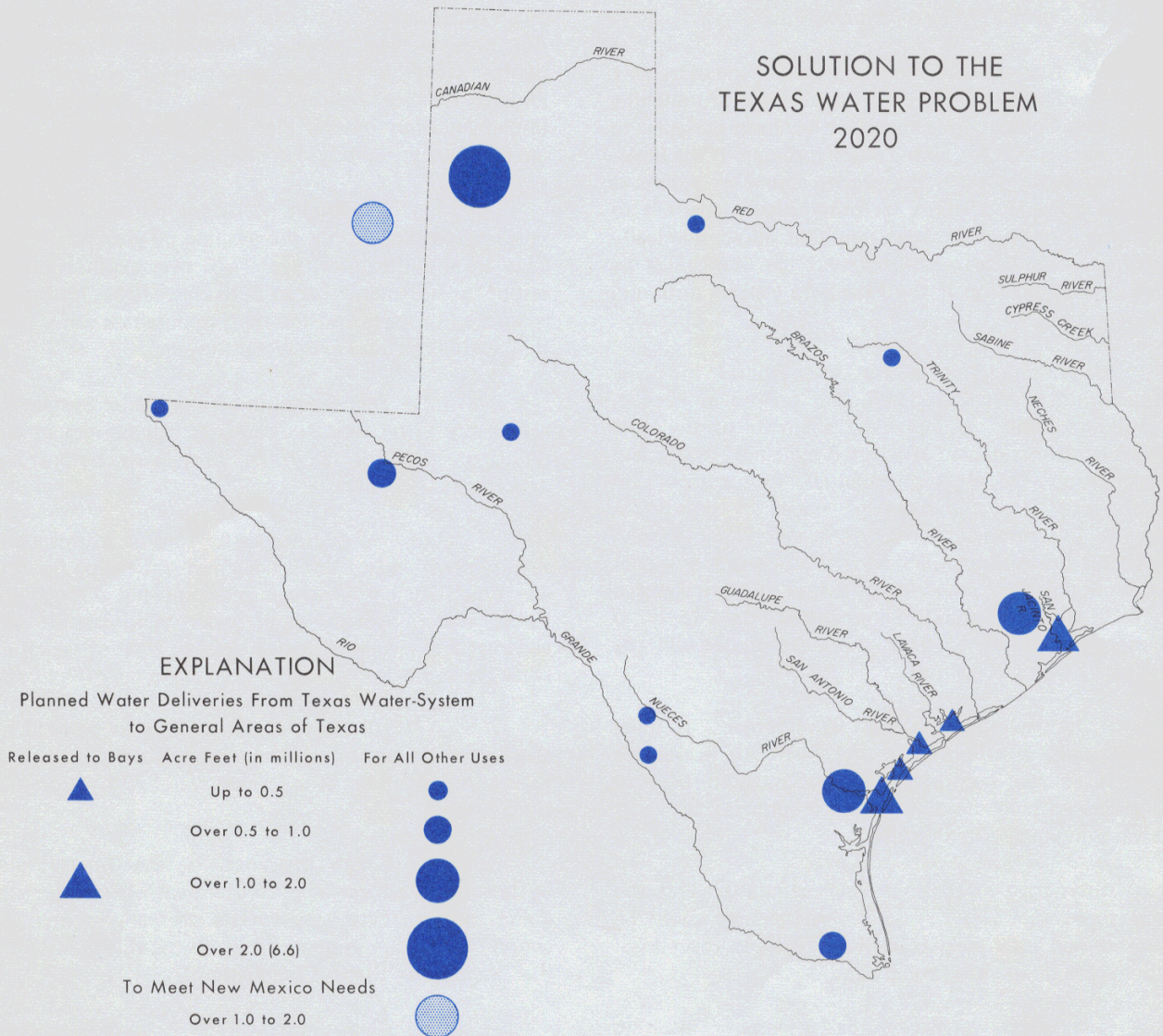
flexible, retaining freedom of choice as to future actions as long as possible.

In developing the Texas Water Plan, the Board has used all historical data that could be accumulated; the resources of a qualified and dedicated staff; and the advice of Federal and State agencies, universities, in-State and out-of-State consultants, river authorities, cities, water districts, and representatives of the various economic segments of the State, as well as the opinions of the citizens of the State expressed during the hearings held by the Board in the summer of 1966.

Recognizing that continuing study and investigation will be needed of future water needs and problems in Texas, the Board nonetheless believes that sufficient information is now available on which to base this comprehensive Statewide Water Plan.

The document has been organized to facilitate its use both by the general public and by technical readers. The supporting data are available in files of the Board, as

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are the reports prepared for the Board's use as a part of the planning document by universities, State agencies, and private consultants. This summary describes the Texas Water Plan and proposes a means for its implementation. Additionally, the Board has prepared a detailed description of the Texas Water Plan providing substantive detail and supporting data on its various aspects.

PLANNING CONCEPTS

Planning is the process by which a prudent society directs its activities to achieve goals it regards as important. It involves more, however, than the formulation of a physical plan—a means of implementation is necessary if planning is to be meaningful. The Board was directed to develop a comprehensive long-range flexible water plan for Texas. Recognizing the complexity of this task—the Board first defined the goals such a plan must

achieve through the coordinated activities of Federal, State, and local levels of government. This conceptual framework has guided planning activities and formulation of the Texas Water Plan, and forms the basis for Plan implementation.

1. The Goal

The objective, or goal, of the Texas Water Plan is to provide in the most effective and economic manner the water supplies and the other benefits to be derived from water development necessary to meet the needs of Texans for all purposes throughout the State as the population grows and the economy expands. National, State, and local interests must be fully considered. Social, cultural, and economic values will be recognized. To the maximum extent possible, the Plan will assure that water supplies of good quality are made available so that the future of Texas will not be limited by lack of water.

2. The Plan to be a Flexible Guide

The Texas Water Plan is a guide for the extremely complex solution to the difficult problem of matching water development to demand. It has been designed to meet water needs for all purposes throughout the State, retaining options as to the proper course of action as long as possible. It must be progressively adapted to changing conditions, recognizing that all economically justified water demands throughout the State must be met as they develop if the Plan is to achieve optimum results.

Water requirements for all purposes must be frequently reviewed, updated, and revised as needed. Feasibility studies of individual elements of the total Plan must be conducted in selected sequence. Design and construction of physical facilities for storage and conveyance of water must be staged at times that provide the optimal balance between water supply, needs for flood control and other purposes, and project economics. A time schedule for action must be adopted to meet Texas' water requirements in time to avoid economic detriment. This time schedule will be extremely difficult to meet.

A framework of project development to meet water needs is proposed in the Plan. All reasonable alternatives have been examined, and must continue to be evaluated with the objective of minimizing the costs of achieving the desired results.

Alternative intrabasin projects compatible with the long-range objectives of water development could be incorporated into the fabric of the Plan to meet local preferences or changing conditions.

Changes in water resource availability resulting from instream development, shifting land use patterns, changes in storage in ground-water bearing formations, effects on flow in streams, flood and drought incidence, and changes in water quality must all be continually analyzed within the context of the Plan. Maximum use must be made of waste waters which can be reclaimed and renovated for beneficial purposes.

The whole range of the State's economy--the effects of water availability and water pricing on location of industry, municipal development, and irrigation expansion--must be evaluated periodically so that water development can be phased to meet changing needs. Opportunities for water-oriented recreation must keep pace with the expanding population.

3. Water Rights

Formulation of the Texas Water Plan has been based upon the premise of no interference with vested rights under existing water right permits. The basin of

origin provisions of the Texas Water Development Board Act provide legal bases for protection of intrabasin rights. There is no comparable legal protection in Federal laws or policies nor in other State statutes. Implementation of the Plan is to be based on these tenets of water rights administration:

(1) Intrabasin needs for all beneficial purposes developing within the ensuing 50-year period will have an absolute priority of right over exportation for out-of-basin demands, as to both water rights for locally sponsored projects and the right to purchase water from the facilities of the Texas Water System.

(2) Demands on the Texas Water System for reasonable intrabasin requirements will be met at any point of time on a 100% firm basis before any exportation.

(3) Water temporarily surplus to intrabasin requirements and to the satisfaction of existing rights at any time, will be conserved and exported through the Texas Water System only under valid permit and contract arrangements, and subject to right of recapture when needed.

(4) All rights under permits to be held by the Board will be obtained through full compliance with rules and procedures of the Texas Water Rights Commission.

(5) Where operation of the Texas Water System might conceivably interfere with beneficial uses under existing rights, appropriate protective terms and conditions will be imposed in water permits granted by the Texas Water Rights Commission.

(6) Agreements will be executed as necessary with holders of existing rights and with operators of other projects, defining such rights as against the Board, and specifying project operational criteria for the Texas Water System to protect usage under such rights, and its operation with that of other projects to maximize overall benefits.

4. Federal-State-Local Relationships

Implementation of the Texas Water Plan and the Texas Water System is to be a coordinated and cooperative effort of the Federal Government, the State of Texas, political subdivisions of the State, and private interests, each acting within the scope of its authority and policies, and within the objectives and framework of the Plan. This arrangement is designed to further the interests of each to the maximum feasible extent. The State will be a major participant, on a partnership basis with the United States, in bringing the Texas Water System into being and in subsequent operation and management of the System.

5. Water Quality

Water quality control is an integral part of water resource development to enable maximum beneficial use, maximum reuse of waste waters, and to preserve the bays and estuaries. At the same time, the necessity to use streams, coastal waters, and ground waters for the final disposal of adequately treated waste effluents is recognized.

For purposes of planning, the achievement of the following goals of water quality management have been assumed: Pollution of Texas' water resources from both man's activities and natural sources will be abated as rapidly as possible, and future pollution prevented. Large-scale regional systems for the collection, treatment, and disposal of municipal sewage and industrial wastes will be planned and constructed where necessary to achieve quality control at reasonable cost. Control of wastes at the source may be necessary in some instances in order to maintain the quality of effluents discharged at levels that will permit reuse.

The compelling factor in water quality control is the health and welfare of Texas citizens. Water quality criteria must be based upon the total use that will be made of the water resource. Low flow augmentation, or low flow control, may be used to bring water quality to levels that will satisfy water uses of the stream on an interim basis, but not as a substitute for the highest economically feasible treatment of wastes.

Reservoir storage space and water will not be permanently and irrevocably allocated to quality control. However, under some circumstances water may be provided for low-flow augmentation, where such water can be used downstream to meet other requirements or to provide fresh water inflows to the bays and estuaries. Where so used, the necessity of continuance will be reviewed at intervals in the light of advances in waste treatment technology, economics, and the need for the storage and use of water for other purposes.

Control of natural sources of quality impairment will be diligently investigated and control measures undertaken where feasible as a means of enhancing usable water resources.

Water development will be undertaken so as to assist the Texas Water Quality Board in achieving effective pollution control, and in assuring fulfillment of the established water quality standards.

6. Multipurpose Development

Dam and reservoir sites in Texas are becoming scarce and costly to develop, and must be preserved and developed to maximum advantage. In general, each water basin, source, site, and facility will be developed on a multipurpose basis, and to its optimum limits. In

examining such multipurpose possibilities, all functions and problems related to the site and the requirements it is to meet will be considered. If it is not economic to build facilities to optimum limits initially, initial development will be planned so that subsequent enlargement is not precluded.

7. Ground Water Use and Conjunctive Use With Surface Water

Whenever feasible, ground water resources will be developed and used on a safe-yield basis. In ground water aquifers subject to overdraft, ground water pumpage will be reduced to safe yield as rapidly as possible by substitution of surface water supplies. Where applicable and feasible, alteration in the pattern of excessive pumping will be considered.

The underground resources of natural ground water and of storage and transmission capacity will be utilized conjunctively with surface water supplies and facilities where such complementary operation will minimize the cost of providing adequate water supplies.

8. Progressive System Development and Coordinated Operation

The Texas Water System is considered as a single integrated unit to be planned, designed, constructed, and operated in such a manner as to minimize the costs of achieving the desired multipurpose results. To achieve this cost minimization objective, elements of the System will be staged and constructed progressively as water demands build up.

The most advanced techniques and automation will be used to operate the system of reservoirs, pumping plants, aqueducts, power plants, and other facilities in a coordinated manner to achieve optimum results.

9. Bays and Estuaries

The coastal bays and estuaries are of great importance to the State of Texas and to the Nation. Adequate fresh water inflows will be provided and other actions taken to preserve and enhance these resources. Comprehensive studies of all bays and estuaries are necessary to determine the proper actions.

10. Intangible Values

Future water development will have a profound impact on the State, politically, economically, socially, and culturally. The full range of impacts and benefits or detriments must be evaluated, even when not measurable in monetary terms. In planning and in project development, therefore, the benefits of esthetic and recreational enjoyment of the water resources of the State will be given full consideration, although these benefits cannot be quantified with precision. Sites of historic and

archeological value will be examined, and measures taken to the fullest possible extent to minimize loss of any of these values as the result of water development. River reaches and springs of great scenic and scientific value will be preserved whenever possible and feasible. All feasible measures will be taken to mitigate any damage to fish and wildlife resources resulting from construction and operation of facilities of the Texas Water Plan, and wherever possible the enhancement of these resources will be included as a project purpose.

11. Need for Equity in Resolving Problems

The construction of the massive impoundment and conveyance facilities of the Texas Water System will have an adverse, although temporary, impact upon the civil functions and economic stability of some local areas. Schools, hospitals, police, fire protection, and other administrative functions will be affected by the large-scale influx of construction personnel. Offsetting these detriments and costs of local communities, to the extent they cannot be handled with local financial resources without hardship, and insofar as the costs are not borne as a Federal responsibility, will be an obligation of the State as part of the construction cost of the System.

12. Master Districts

The reimbursable costs of the facilities of the Texas Water System allocated to water supply will be secured in full by water service contracts executed by the State with legally and financially viable master districts. Such districts must be formed in areas where no such entity presently exists, and must have adequate powers to raise sufficient revenue through water charges or taxation to assure that costs of providing water to the district through the System will be repaid. Where irrigation is a use to be served, a master agency or conservancy district will contract for the delivery of water to one or more wholesale delivery points within the area involved. Distribution of the water to retail consumers will be accomplished by the master agency or district or under ancillary contracts with other political subdivisions within the master agency.

Such agencies or districts will have adequate revenues, derived either from executed water sales contracts, or tax revenues, or both, to assure that the Federal and State investment for capital costs and the annual costs will be repaid insofar as these costs are reimbursable under Federal and State laws and policies. It will be important to assure economically effective farm units within irrigation areas to meet the costs of water supply.

13. Master Plans and River Basin Comprehensive Plans

The Texas Water Plan has been formulated incorporating previous master plans and comprehensive plans for river basin development to the fullest possible advantage.

All elements of such plans not in conflict with the overall objectives of the Statewide comprehensive Plan can be developed as a part of the on-going development of water resources of the State.

In the resolution of any conflicts that may arise, consideration of means for enhancement of the economic and social well-being of the river basin will be a principal objective as well as consideration of the Statewide interest.

14. Interstate Compacts

The apportionment of water from sources flowing along or across the boundaries of Texas will be made on the basis of jointly conceived compacts between the States involved and approved by the United States. On streams where compacts have not yet been consummated, it is expected that continued efforts will be made to reach agreement on the equitable apportionment of the waters.

15. Energy for Pumping

Extremely large amounts of energy for pumping will be required for the Texas Water System, and costs for energy will be a major component of cost of supplying water under the System. New generating facilities and expanded transmission systems will be necessary, and should be the lowest cost facilities feasible for supplying these needs. These will be fully integrated with the regional power systems. Surplus capacity and energy available from the regional systems will be used where financially advantageous.

16. Water Service Contracts

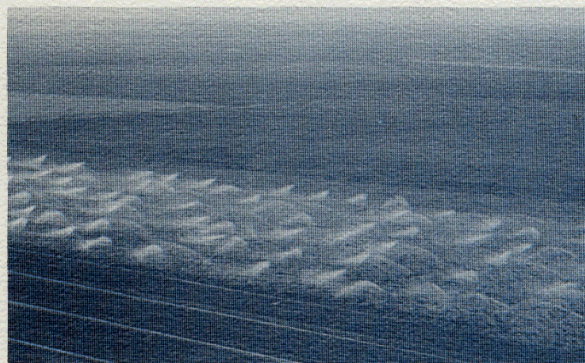
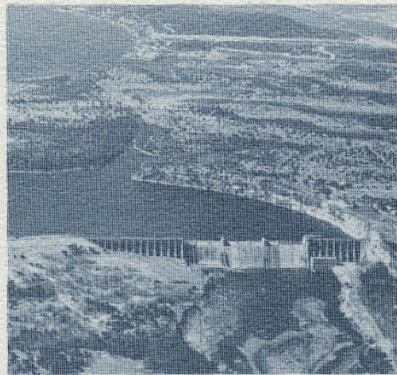
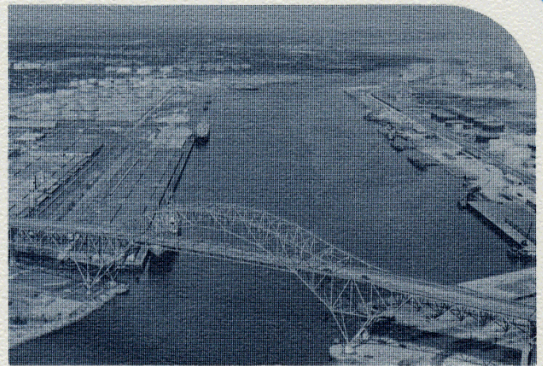
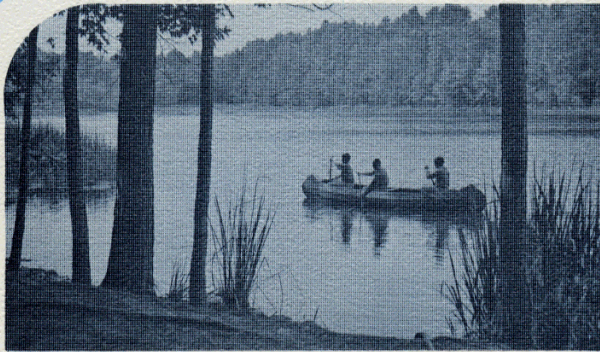
The water service contracts to be executed between the State and local political subdivisions served by the Texas Water System will convey a contract right to a water supply of suitable quality without specifying the exact source or sources from which the water will be obtained. The contracts will specify the amounts, timing and places of delivery, and the amounts and manner of payment and will contain such other terms and conditions as necessary to protect the interests of the United States, the State, and the contracting agency.

17. Water Pricing and Repayment Policy

The formula for payments for water under water service contracts will be such as to assure the State, as operator of the Texas Water System, of sufficient revenues to meet its financial obligations to the United States to the extent these pertain to water supply, to repay the State's investment allocated to water supply, and to operate and maintain the water supply components of the System.

Pricing and repayment for water for irrigation will be in accordance with the provisions of Federal Reclamation Law, as an investment by the United States. Other pertinent Federal laws and policies will apply with regard to reimbursement of the remainder of the Federal investment. The State's investment will be repaid with interest.

Pricing and repayment for municipal and industrial water supplies will be by zones, with the price for water increasing as the distance of conveyance increases.



The Texas Water Plan



THE TEXAS WATER PLAN

Its Objectives

The Texas Water Plan is a flexible guide to the coordinated, long-range management, development, and redistribution of Texas' water resources, and for the importation of water from out-of-State for the benefit of Texans throughout the State.

The several regions of the State are interdependent economically, financially, and politically. One region with water surpluses cannot retain those surpluses in excess of its own needs to the detriment of other regions less fortunately endowed with water resources without loss to its own well-being and to the State as a whole. Concerted, aggressive action is required if adequate funds are to be available for the full development of water and facilities that will be necessary throughout the State. The Texas Water Plan will provide a sound basis for such action.

The Plan is based on the premise of the following accomplishments being achieved effectively and economically through cooperative coordinated action by the Federal agencies, State agencies, local political subdivisions, and private interests.

(1) Satisfy vested water rights with proper modes and procedures to be followed for the equitable adjustment of any water rights that might be affected by the program, including continuance of vested riparian rights now supplied by direct diversion from streams.

(2) Provide the projected 2020 municipal and industrial water requirements throughout the State.

(3) Provide for the importation of an estimated 12 to 13 million acre-feet per year from out-of-State sources by 2020 to meet Texas' water needs, and deliver 1.5 million acre-feet to New Mexico through joint use of facilities.

(4) Deliver about 7.5 million acre-feet of supplemental water annually for irrigation in North Central Texas, the High Plains, and the Trans-Pecos area. Planning will continue as to possible import of water to supply additional economically justified water needs throughout the State, as those needs arise.

(5) Deliver 727 thousand acre-feet of water annually for irrigation in the Coastal Bend area and 700 thousand to the Lower Rio Grande Valley through the Coastal Canal; and make available 200 thousand acre-feet annually for irrigation in the Winter Garden area and 190 thousand acre-feet annually for irrigation in Webb and Maverick Counties by releases from Amistad Reservoir, with water supplied to the Lower Rio Grande Valley through the Coastal Canal in replacement for these releases.

(6) Based on best available estimates of need, provide regulated fresh water inflows to the bays and estuaries, and participate as justified in other measures such as structural modifications to obtain better tidal circulation, with the objective of maintaining suitable quality conditions for fish and shellfish.

(7) Supply projected water requirements for wildlife management areas and refuges.

(8) Meet projected water requirements for secondary oil recovery programs.

(9) Recognize interstate compact commitments.

(10) Use return flows and reclaimable waste waters to the maximum feasible extent.

(11) Through conjunctive use of surface and ground water and other measures, make possible a decrease in ground water extractions from aquifers to the safe yield, thus minimizing subsidence and other adverse effects of overdraft.

(12) Decrease loss of the State's water resources through control of phreatophytes and salvage of phreatic non-beneficial consumptive uses.

(13) Provide flood control through storage in proposed reservoirs, and by channel improvements and levees where necessary.

(14) Coordinate hurricane protection projects along the Gulf Coast with other actions in order to minimize the adverse effects of those projects.

(15) Support projects to provide drainage where feasible for land reclamation and where necessary for maintenance of agricultural productivity.

(16) Alleviate degradation of the State's fresh water resources from sources of naturally poor quality water, such as saline springs.

(17) Develop means to provide regional systems for the collection, treatment, and disposal of municipal sewage and industrial wastes that will be necessary to maintain the quality of the State's waters at requisite levels.

(18) Develop other necessary means for quality protection and management.

(19) Preserve and protect river reaches and springs of great scenic beauty or scientific value.

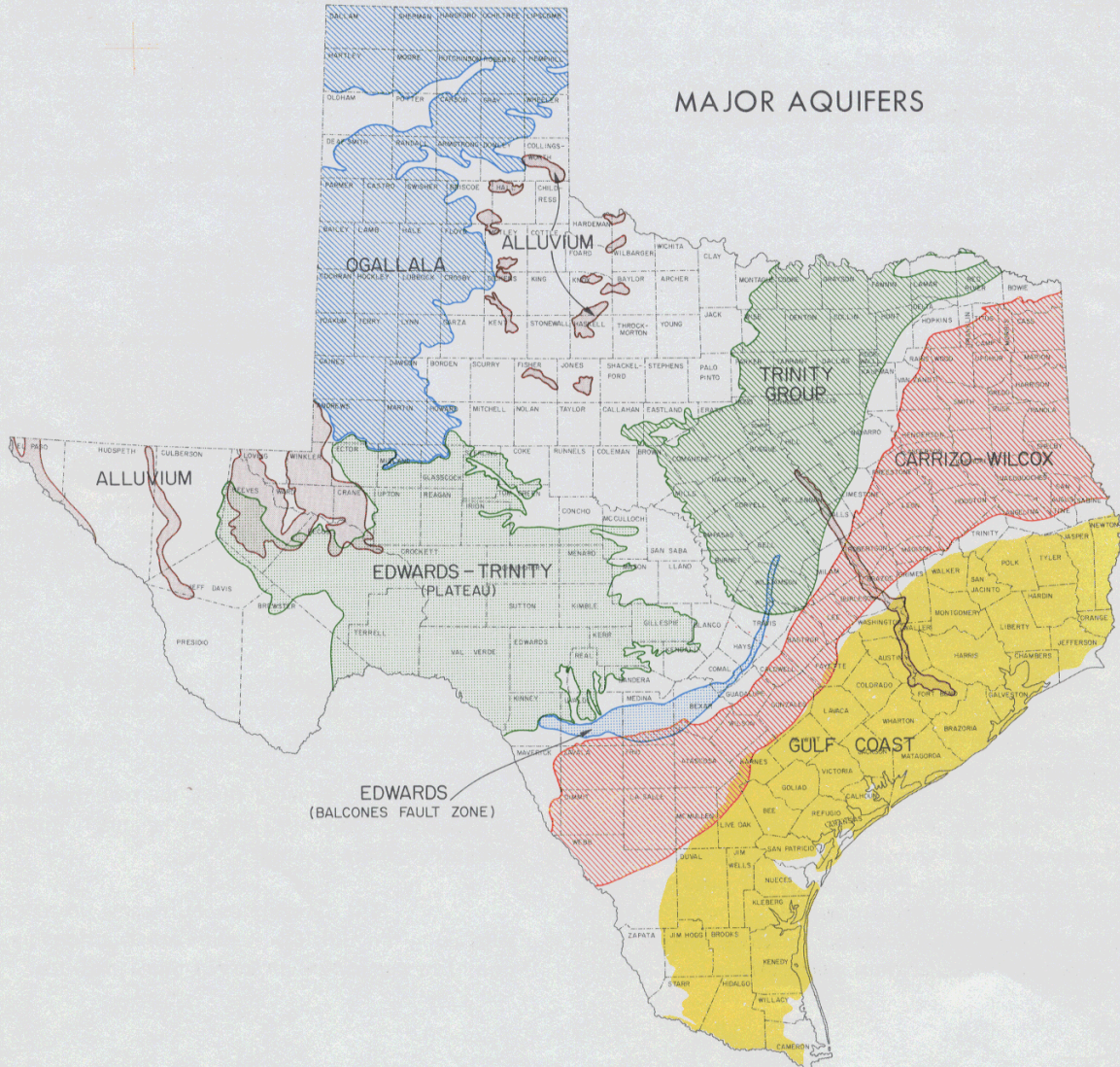
(20) Preserve and protect sites and natural phenomena of historic and archeological importance.

(21) Provide additional water-associated recreational opportunities.

(22) Integrate feasible navigation projects on Texas streams with other water development objectives, and provide necessary water requirements for navigation purposes.

(23) Provide for expanded upstream watershed programs for erosion control and land treatment, and additional floodwater retarding structures and channel improvements.

(24) Generate electrical energy for pumping to the extent that energy cannot be made available from other sources at requisite prices.



(25) Develop hydroelectric power where feasible.

(26) Protect and enhance fish and wildlife resources to the maximum feasible extent.

(27) Provide increased financial assistance to qualified local agencies for necessary water facilities.

Water Resources

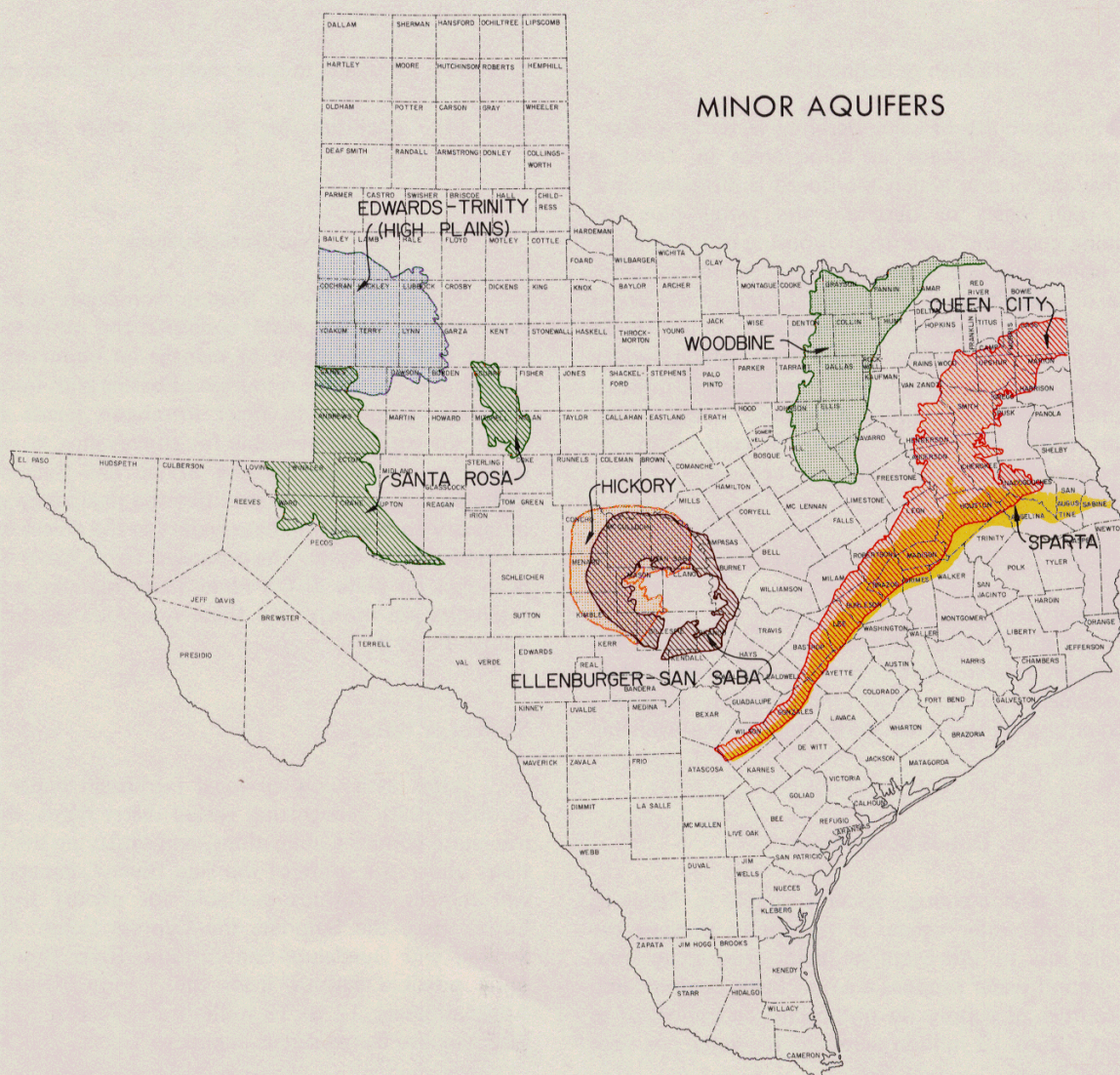
The total water resources of the State have been evaluated in planning studies, including waters from surface streams of Texas (surface waters); water from underground formations (ground water); treated or untreated waste waters (return flows); brackish and saline waters; and atmospheric water for possible increases in rainfall. Studies have also been undertaken of possible importation of water from out-of-State sources.

Surface Water

The amount of water flowing in Texas streams ranges widely from east to west as does the amount of water falling as rain or snow. The average annual runoff is about 39 million acre-feet, with about three-fourths of this total coming from the eastern one-fourth of the State. The annual amount of runoff varies widely also. For the period 1940-46, the average annual amount was approximately 59 million acre-feet, dropping to about 24 million acre-feet annually for the dry period 1950-56.

Ground Water

Ground water is a significant resource throughout much of the State, supplying about 75% of the total water used for municipal, industrial, and irrigation purposes. Many areas now supplied by ground water are depleting the available supply because the rate of pumping grossly exceeds the rate of replenishment. As



ground water is depleted, those areas must meet their needs through a supplementary source. In areas where serious overdrafts occur, corollary problems of land subsidence and intrusion of poor quality water may impose additional hazards.

Return Flows

Much of the water diverted from a stream or pumped from underground formations for municipal and industrial use is returned to a stream channel as treated waste water. Some of the water used for irrigation also returns to the stream or aquifer. As water uses increase in the future, the volume of return flows will increase. As the new sources of water which can be exploited are strictly limited, methods of renovating return flows for reuse must necessarily be employed.

Present municipal and industrial waste-water releases are estimated at 0.8 and 1.3 million acre-feet per year, respectively, and are projected to reach 5.9 million acre-feet by 2020.

Brackish or Saline Waters

The possibility of using desalted water as a means of meeting water needs in some areas in Texas is attractive and one to which the Board is directing close study. High costs of desalting the water plus the continuing costs and hazards of disposing of the concentrated brines produced under present technology tends to rule out desalting as a solution to large-scale water supply problems. However, in local areas desalting shows great promise. Technological advances which reduce costs and solve some of the waste brine disposal problems could offer additional promise in the future. Brackish water will supply a large percentage of the water requirements for secondary oil recovery.

Weather Modification

Research studies of the potential for modifying rainfall are still in relatively early stages. Although the Board is not foreclosing this potentiality, present planning does not rely upon weather modification as a means of augmenting in any substantial amount the available water supply.

Out-of-State Import

There is not enough water available in Texas to supply future water needs. If we are to prevent the economic loss to the State of major geographic areas where ground water supplies are now being depleted and other sources of supply do not occur, an import of as much as 12 to 13 million acre-feet of water per year

must be sought. Water in these quantities appears from preliminary planning estimates to be available from the Mississippi River at a point below diversions from the River in Louisiana. For purposes of planning, it was assumed that this diversion of water could be made possible.

The New Mexico State Engineer's office has indicated that import of approximately 1.5 million acre-feet of water per year will be required by the year 2020 to maintain existing irrigation development and the associated expanding economy in Eastern New Mexico. It has been assumed that this need could also be met from the Mississippi.

Description of Physical Works

The physical works required to accomplish the objectives of the Texas Water Plan are categorized as:

- (1) The Texas Water System,**
- (2) Interstate System,**
- (3) Projects to meet local requirements, and**
- (4) Facilities for purposes other than water supply.**

Texas Water System

The Texas Water System comprises the dams, reservoirs, pumping plants, conduits, and other facilities which will be necessary to manage an imported water supply and the water resources of basins with interim or long-term surpluses to meet intrabasin needs and to make the surpluses available for conveyance to areas of deficiency elsewhere in the State. The System also includes the conveyance facilities and regulatory storage necessary to transport these waters to the places of need throughout the State. The proposed Texas Water System is shown on Plate 2. On Plate 3 existing and proposed reservoirs are shown, and these reservoirs are listed on Tables 1 and 2.

Sources of Water

After satisfying all local intrabasin water needs through 2020, recognizing vested water rights, meeting interstate compact obligations, and satisfying the obligations under the draft of the Red River Compact, there will remain a surplus available for export from the Lower Red, the Sulphur, the Cypress Creek, Neches, Sabine, and Guadalupe-San Antonio River Basins, and some possible surplus from the Trinity River Basin. Approximately 12 to 13 million acre-feet of water per year will also be needed as import to Texas.

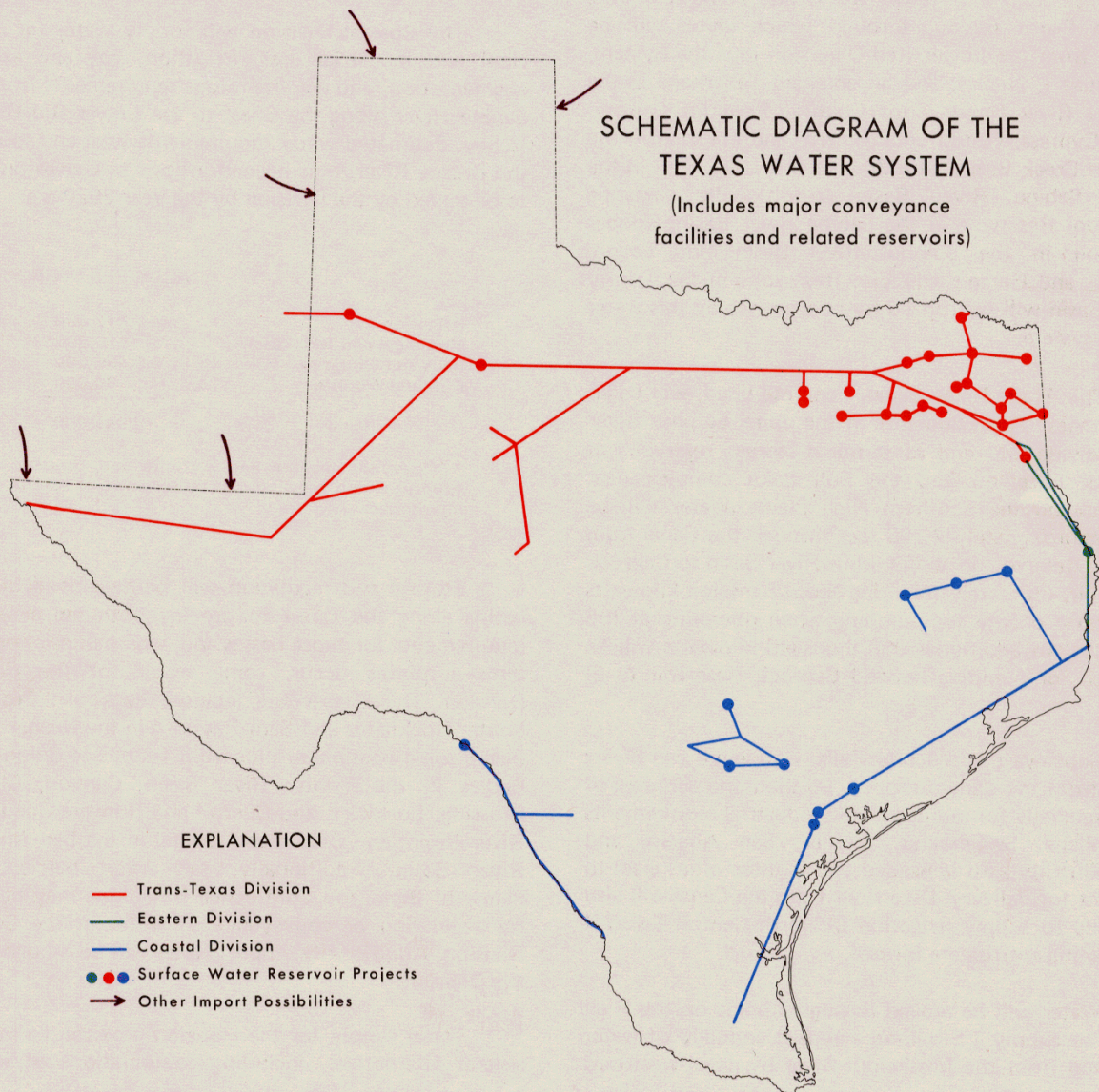
Some supplies of water may be available on an interim basis from basins where water supplies are in excess of present water requirements or water requirements projected to 2020. Use of these waters on an interim basis when intrabasin supplies are in excess of requirements will permit the most economical and efficient phasing of construction, and result in a lower unit cost of water to all concerned including intrabasin users. Some of these basins where temporary interim use is proposed will ultimately need supplemental water through the System to meet intrabasin requirements in excess of intrabasin supplies.

Physical Elements and Purposes

The physical facilities comprising the Texas Water System shown on Plate 2 are: (a) the **Trans-Texas Division**, including the storage and regulating reservoirs and the interconnecting conduits and pumping plants in the Northeast Texas basins, the Trans-Texas Canal, and

the terminal reservoirs and wholesale distribution systems; (b) the **Coastal Division**, including the Coastal Canal, storage and regulating reservoirs from the Sabine River to the Lower Rio Grande Valley, conveyance from the Rio Grande of releases from Amistad Reservoir to the Winter Garden area, and the storage and conveyance complex in the Guadalupe and San Antonio River Basins; (c) the **Eastern Division**, comprising those works in the eastern basins required to move water from the point or points of delivery to Texas of water imported from out-of-State sources to the Trans-Texas and Coastal Divisions.

Distribution systems to supply irrigation users will be constructed from wholesale delivery points by the master districts to be served with water for irrigation purposes under the Texas Water System. These systems for distribution will be a local area responsibility. Their design and repayment of their costs will be subjects for local decision.



The **Trans-Texas Division** will supply all municipal, industrial, and irrigation requirements in the Northeast Texas basins and the Dallas-Fort Worth area. The following amounts of water will be transported through the Trans-Texas Canal for Dallas-Fort Worth, North Central Texas, the High Plains, the Trans-Pecos area and El Paso, and to New Mexico.

ACRE-FEET PER YEAR

Municipal & Industrial	950,000
Irrigation	7,584,000
New Mexico	1,500,000*
Total	10,034,000

* Water imported from out of Texas.

Storage and regulating capacity will be developed in reservoirs in the Northeast Texas basins to provide fully the projected requirements of those basins, and to supply water to the Trans-Texas Canal. These reservoirs include Pecan Bayou, through which water will be moved from the Lower Red Diversion into the System; Parkhouse I, Naples, and an enlarged Texarkana in the Sulphur River Basin; Titus County, Franklin County, Black Cypress, Caddo enlargement, and Marshall in the Cypress Creek Basin; and Mineola and Lake Fork in the upper Sabine River Basin. Additionally, existing Tawakoni Reservoir in the Sabine River Basin, Cooper Reservoir in the Sulphur River Basin, and Lavon, Forney, and Garza-Little Elm Reservoirs in the Trinity River Basin will be utilized for conveyance by this water supply system.

The Trans-Texas Canal, concrete lined, will begin at Northeast Texas Junction at the upper Sulphur River Basin divide and end at terminal storage reservoirs at Caprock Reservoir and the Bull Lake complex near Lubbock on the Southern High Plains. Water will be lifted approximately 2,700 feet through the Canal from Cooper Reservoir in the Sulphur River Basin to Caprock Reservoir, ultimately requiring about 5 million kilowatts of electric energy for pumping when operating at full capacity. An additional 950 thousand kilowatts will be required for pumping beyond Caprock Reservoir to El Paso.

Southwest of Wichita Falls, a pipeline can divert water from the Canal to supply 95 thousand acre-feet of water annually for municipal and industrial requirements of Abilene, Sweetwater, Snyder, San Angelo, and Colorado City as it is needed and if these cities elect to contract for delivery. Diversions from the Canal will also be made to supply irrigation in North Central Texas if contracting entities are formed.

Water will be moved through storage on the High Plains to supply 1.5 million acre-feet annually of water imported from the Mississippi River by canal westward

from Bull Lake Reservoir to New Mexico. South from storage, Caprock Reservoir and Bull Lake, water will be conveyed by canal to supply 505 thousand acre-feet of water annually for municipal and industrial use—80 thousand acre-feet for Lubbock, 140 thousand acre-feet for Midland-Odessa, 45 thousand acre-feet for Big Spring, 40 thousand acre-feet for Pecos, and 200 thousand acre-feet by pipeline from Pecos to El Paso—and 933 thousand acre-feet annually for irrigation in the Trans-Pecos. Additional water can be supplied in the El Paso area and Hudspeth County for irrigation purposes by enlargement of the capacity of the System.

Distribution systems will be needed in North Central Texas, the High Plains, and the Trans-Pecos for irrigation water. The canal conveying water from a point near Lubbock to the Trans-Pecos will be a main artery of the distribution system on the High Plains. Other than this main canal, these distribution systems will be constructed and operated by districts formed in the area they serve.

The **Coastal Division** will supply water for municipal and industrial uses, irrigation, bay and estuary augmentation, and wildlife refuge requirements from the Sabine River along the Coast to the Lower Rio Grande Valley. Estimated water requirements west and south of the Brazos River, plus needed inflows to Galveston Bay, to be served by the Division by the year 2020 are:

ACRE-FEET PER YEAR

Irrigation	1,817,000
Municipal and Industrial	518,000*
Bays and Estuaries	2,450,000
Fish and Wildlife	60,000
Total	4,845,000*

* Does not include San Antonio and Houston supply, which may be met by any one of several alternatives.

Storage and regulation will be developed in river basins along the Coast to provide both the projected requirements for those basins and, where interim or long term surpluses occur, some water for the Coastal Division. These reservoirs include Blackburn Crossing, Ponta, Rockland, and Sam Rayburn in the Neches River Basin; some possible surplus from Tennessee Colony and Bedias in the Trinity River Basin; Canyon, Cloptin Crossing, Lockhart, and Cuero I and II in the Guadalupe River Basin; and Cibolo and Goliad in the San Antonio River Basin. Additionally, salt water barriers and Palmetto Bend and Confluence Reservoirs may be used for regulation or conveyance of water in the Coastal Division. Additionally, import water will be brought into the Division.

Water supply for the Houston area can be met by several alternatives, including combinations of supply

from the Trinity, San Jacinto, and Neches River Basins, ground water, and water from the Coastal Canal. These alternatives include diversion from the Neches River Basin through the canal system of the Lower Neches Valley Authority under appropriate water permits and contracts; water from the Coastal Canal; diversion of water from Rockland Reservoir to Bedias Creek Reservoir and into the San Jacinto System; or treatment of Trinity River water and its direct municipal use.

Fresh water inflows needed for Galveston Bay, now estimated at 1.5 million acre-feet annually, may be revised by studies now underway. These needs can be supplied from the Coastal Canal, in whole or in part.

Cuero, Cibolo, and Goliad Reservoirs and a pipeline conveyance system are a part of the Coastal Division. Through systems operation, San Antonio can be supplied from this source with 220 thousand acre-feet of water annually to supplement available ground water from the Edwards (Balcones Fault Zone) Aquifer. Further, these reservoir developments will allow early use of interim basin surpluses in the lower coastal areas.

Conveyance of releases of water out of Amistad Reservoir to the Winter Garden area will be down the river channel, then through canal and pump station across the divide to terminal regulating storage. Delivery point in the Winter Garden area will be determined by feasibility and design studies conducted in coordination with local interests. Water supplied from Amistad to irrigators in this area and in Webb and Maverick Counties will be replaced in the Lower Rio Grande Valley by deliveries through the Coastal Canal. Areas thus supplied will be required to assure the repayment of the reimbursable costs for the delivery of the replacement water from the Coastal Canal and for diversion facilities from the Rio Grande. Distribution systems, constructed and operated by local master districts, will be needed in the Coastal Bend, Lower Rio Grande Valley (except where existing systems are adequate), Webb and Maverick Counties, and the Winter Garden area.

The **Eastern Division** includes those works required to move water imported from out-of-State sources to the Trans-Texas and Coastal Divisions. At the time of release of this report, planning for such an import must, of necessity, be adaptable to any one of several alternative points at which such an import supply might be delivered to the Texas State line. Final decision will be conditioned by the results of feasibility studies by the Corps of Engineers, studies by the Mississippi River Commission, and by the future water needs of the State of Louisiana which might also be served by works carrying an import supply to Texas and New Mexico.

Principal alternatives being considered are a coastal routing which would bring import water to the State line at the eastern terminus of the Coastal Canal on the

Sabine River; a combination of import with the authorized Red River navigation project; or some combination of these or other routings.

If the water is brought along the coastal route, then works of the Eastern Division would convey water northerly into the Trans-Texas Division. Alternatively, water imported to a northerly point, such as the Red River, would supply water to the Trans-Texas Division, and south to supply the Coastal Division (See Plate 2).

Design studies of some eastern basin reservoirs will be guided by the operational requirements imposed by the direction in which water ultimately is moved through the Eastern Division.

Staging

Before construction of any conveyance unit of the Texas Water System is begun, there must be assurance of an import water supply. This is necessary to avoid the risk of constructing System units or committing interim water surpluses to meet water needs for which there might not be a sufficient assured long-term water supply.

Once an import of water from the Mississippi River has been assured through appropriate agreements and Congressional authorization and funding, maximum efficiency at minimum cost can be achieved by staging construction of storage, conveyance, and irrigation distribution facilities over time as water needs increase. Constraints of design and construction capability and the availability of funds are key factors in determining the rate at which facilities can become operational.

Subject to the results of feasibility studies, the Board proposes that design and construction should begin in the following sequence, and proceed concurrently on:

A. (1) Storage facilities in Southwest Texas and the Coastal Canal from the Lower Rio Grande Valley, utilizing temporary surpluses in basins west of the Guadalupe River on an interim basis, and building eastward as intrabasin demands and requirements of service areas absorb these temporary surpluses. Construction on the Coastal Canal will continue progressively eastward from the Guadalupe River as rapidly as possible to assure delivery of water through the Canal from the east by the time interim surpluses are required for inbasin users and additional supplies are needed as a supplement to meet total water requirements within these basins and to supply their service areas.

(2) Storage and conveyance facilities in the Northeast Texas basins.

B. The Trans-Texas Canal and storage and distribution facilities in the High Plains and North Central

Texas areas. As the construction on the Trans-Texas Canal to Bull Lake is completed and construction begins on the Canal southward toward Pecos, construction should begin on the distribution system in the Trans-Pecos and on the pipeline to El Paso.

C. The conveyance facility from the Mississippi River to the State line.

Water available as surplus from the Northeast Texas basins would move westward first, supplying the requirements in the Dallas-Fort Worth area as needed, and initiating deliveries through the Trans-Texas Canal.

As facilities from the Mississippi River are completed, additional water to West Texas, plus the 1.5 million acre-feet annually for New Mexico, would be moved through the Trans-Texas Division facilities as rapidly as municipal demands increase and as irrigation distribution facilities are constructed to serve the land.

When the Coastal Canal is completed east to the Sabine River, Mississippi River water can be brought directly into the Coastal Division to supplement eastern basin water providing 2020 projected requirements in the areas supplied by the Coastal Division.

At this phase the Texas Water System would be fully operational.

Energy for Pumping

The total power and energy requirements for pumping under the Texas Water System will exceed the present requirements of any region of the State. Although natural gas engines may supply smaller installations, most of the energy must come from electrical generation.

The alternatives for supply of electrical energy for System pumping include:

- (a) Purchase from existing utility systems.
- (b) Construction and operation by the Board of a State-financed generating plant(s).
- (c) A Federally financed and constructed generating plant or system. This would produce the lowest cost energy, particularly for pumping irrigation water since no taxes or interest component would need to be included in the cost.
- (d) A very large capacity nuclear or mine-mouth generating plant(s) financed in part with public funds, Federal and State, and in part by private investment, and constructed and operated by the investor-owned utilities.

Of these alternatives, the last appears to be the most feasible because it would achieve the economies of large scale; cost of energy for System pumping would not include a component for taxes or profit, nor, in the case of irrigation pumping energy, an interest component; and the required Federal and State investments would be held to a minimum.

Transmission and distribution of energy for pumping would be accomplished by:

- (a) A publicly financed system, Federal or State or both, designed and constructed for the purpose; or
- (b) Wheeling (conveying) over the existing utility systems, expanded and reinforced as necessary; or
- (c) A new system financed and operated similar to the provisions of alternative (d) for providing electrical energy.

Interstate System

In its preliminary plan released early in 1966, the Board described the imperative need for an out-of-State import of water if a major loss of irrigated agriculture were to be avoided in the West Texas area, notably the High Plains. With the support of the Board, local interests, the Texas Congressional delegation, and widespread support throughout Texas, the Congress of the United States authorized preliminary studies of importation sources and routes from the Mississippi River for these water-deficient areas by the Mississippi River Commission and the Lower Mississippi Valley Division of the U.S. Corps of Engineers participating with the Bureau of Reclamation.

Extremely preliminary indications, plus reconnaissance water studies and economic analyses made by the Board, suggest that feasibility studies of an import routing to Texas and eastern New Mexico from the lower Mississippi River are warranted. The route through Louisiana for such an import might follow the channel of the Red River, entering Texas in the Cypress Creek Basin, or might be a part of a fresh water coastal channel constructed westward to the lower Sabine River from the Mississippi River, or a combination of these two or other routings.

No decision on the relative merits of the routes, or a combination thereof, is possible at this time, and the Texas Water Plan is, therefore, so designed as to be compatible with alternative possibilities.

Projects to Meet Local Requirements

These facilities are shown in summary form in Tables 1 and 2 and are illustrated on Plate 3. The selection of the projects shown here was based on the premise that ground and surface water in each river basin would be developed to the maximum practicable extent, that exports from basins of surplus would be limited to those quantities of water available over and above reasonably foreseeable 50-year basin needs, and that import to areas of deficiency would be limited to that water needed to supplement locally developed supplies. In the studies leading to completion of the Plan, the Board examined the feasible alternatives available and made exhaustive studies of new alternatives proposed by various interests.

The omission of a local project from Plate 3 or Tables 1 and 2 does not preclude the possibility that that project may ultimately be constructed. By the same token, the inclusion of a project does not mean that it is the only project to be considered. Rather, each such

project must be examined on its own merits on the basis of its potential for meeting the basic objectives of the Texas Water Plan, and its merit from the standpoint of Statewide planning for optimum water resource development.

It is envisioned that most of these projects will be constructed under local sponsorship, either by one of the Federal agencies or by a local agency with financial assistance when necessary from the Board.

Water Projects Other Than Water Supply

These projects include navigation, both along the Coast and on inland rivers, flood control facilities other than reservoirs providing water supply storage, hydro-electric power generation, hurricane protection projects, upstream watershed-protection programs, drainage of wetlands, natural salinity alleviation projects, and phreatophyte control projects.